

Laser ranging in Main metrological center of the Russian State service of time, frequency and the Earth rotation parameters determination.

THE HEAD METROLOGY CENTRE OF TIME AND FREQUENCY STATE SERVICE FEDERAL STATE UNITARY ENTERPRISE «VNIIFTRI», 141570, Mendeleevo, Moscow region, Russia

S. Donchenko, I. Blinov, I. Ignatenko, E. Tsyba

The article deals with activity of FSUE VNIIFTRI in the field of satellite laser ranging (SLR) and Lunar laser ranging (LLR).

Introduction

Federal State Unitary Enterprise «All-Russian Research Institute of physico-technical and radio-technical measurements » is one of the leading national institutes of metrology in Russia. One of the main divisions of the Institute is the Main Metrology centre of time and frequency state service.

Now VNIIFTRI has 2 SLR stations «Mendeleevo-1874» and SLR station «Irkutsk1891» in the East-Siberian Branch of VNIIFTRI in the city of Irkutsk. Stations parameters «Mendeleevo - 1874» and SLR station «Irkutsk - 1891» are:

- Operating wavelength 0.532 micron;
- Frequency 300 Hz;
- Pulse duration of 250 ps;
- Pulse energy 2.5...2.7 mJ;
- Beam divergence 7...12 arcsec;
- The diameter of the receiving aperture and TV Guide is 25 cm.

SLR stations was produced in Russia in 2011. Stations «Mendeleevo 1874» (left) and «Irkutsk 1891» (right) are presented in Fig. 1.



Figure 1 Stations «Mendeleevo 1874» (left) and SLR station «Irkutsk 1891» (right)

VNIIFTRI uses SLR stations together with:

- State time and frequency standard in Mendeleevo UTC(SU);
- State standard of length in Mendeleevo;
- Secondary time and frequency standard in Irkutsk city.

Additional equipment:

- Mobile laboratory with mobile TWSTFT station and active H-maser;
- Fixed TWSTFT station in Mendeleevo;
- Standard of comparison - Leica TDA 5005.

The main directions of using laser ranging at FSUE VNIIFTRI are Time and frequency transfer and Earth rotation parameters determination.

Time and frequency transfer techniques based on different technologies

Despite VNIIFTRI doesn't participate in Jason-2 Time Transfer by Laser Link (T2L2) campaign we started domestic analogous experiments using GLONASS # 747. Three laboratories are involved in this activity: VNIIFTRI (Mendeleevo-1874), VNIIFTRI ES branch (Irkutsk-1891), and GLONASS master station. Using laser ranging instruments for the first time in history GNSS time scale has been transferred from one remote laboratory to the other one. Till now the main source of uncertainty is line link between on land local time scale and laser station itself.

VNIIFTRI has a modern equipment for one-way time calibration using the SLR equipment. The difference between ground clock and GLONASS PRN 747 satellite clock determined with the help of this device are showed in figure 2. The total uncertainty is about 0,9 ns.

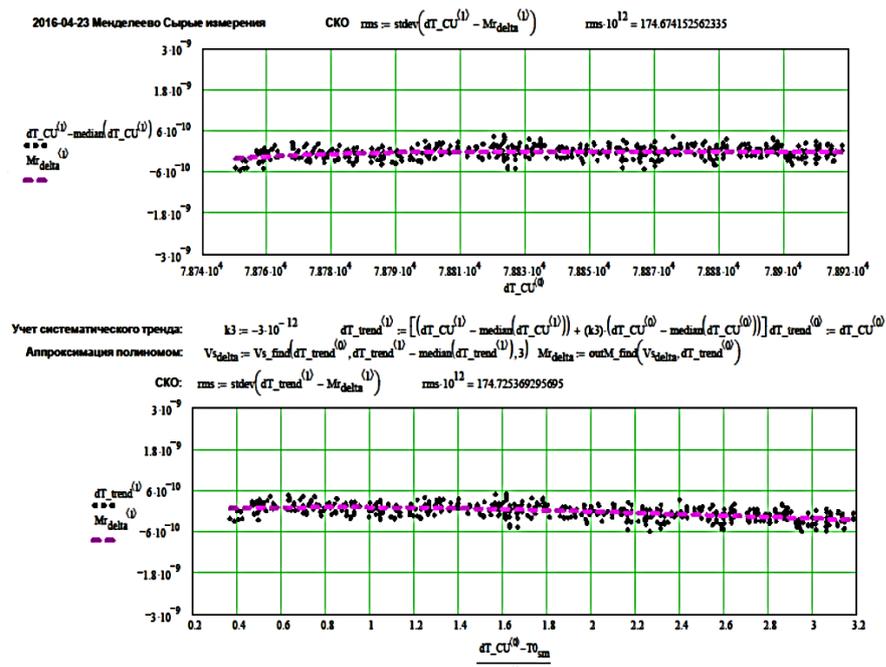


Figure 2 The difference between ground clock and GLONASS PRN 747

Determination of the parameters of the earth's rotation [1, 2]

The Main Metrology centre of time and frequency state service was founded based on the Head office of the unified time service and has been actively defining Earth rotation parameters based on co-processing of the entire measurement data since 1955.

The EOP activities at VNIIFTRI can be grouped in four basic topics:

- processing GNSS, SLR , LLR and VLBI observation data for EOP evaluation;
- combination of EOP series for evaluation of reference EOP values (on the EOP raws level and observation level);
- combination of GLONASS/GPS satellites orbit/clock;
- providing GNSS and SLR observations at five metrological sites acting under the auspices of Federal Agency on Technical Regulating of Metrology(ROSSTANDART).

Regular computing of Earth rotation parameters (ERP) according to the measurements data using satellite laser rangers (SLR) started in the Main Metrology centre of time and frequency state service in 1995. In 2010 the processing of SLR measurements had to be suspended due to technical reasons. Nowadays the processing of laser measurements is resumed.

The results of determination of EOPs with combined SLR data of Lageos 1 and Lageos 2 are presented in Fig.3. Comparing it with the concurrent EOP (IERS) C04, the agreement is as good as 0.1 mas for the polar motions X_p and Y_p .

EOP from satellite laser ranging (SLR) Lageos 1,2

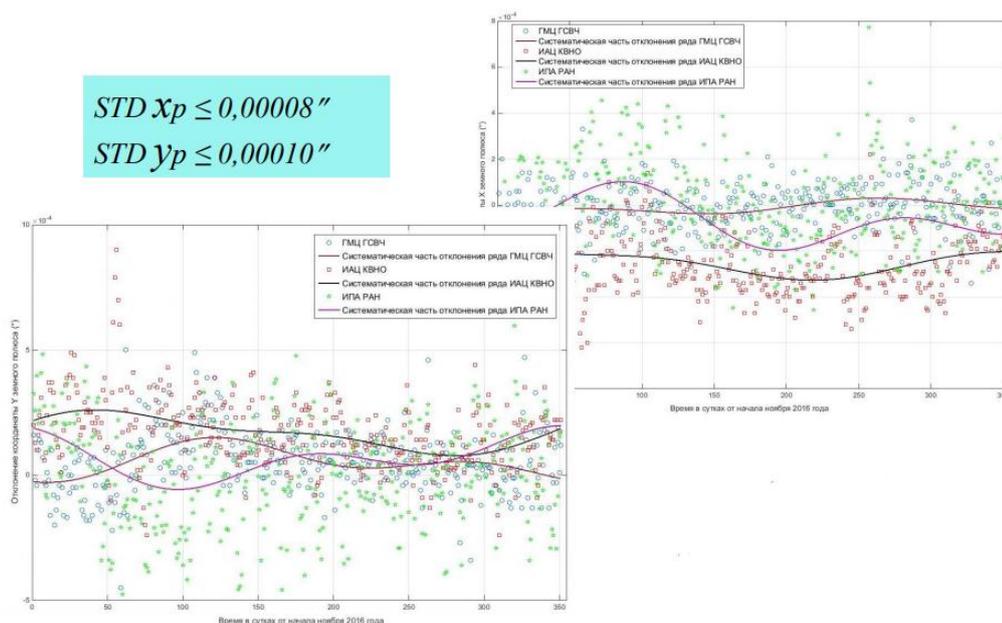


Figure 3 Determination of EOPs with combined SLR data of Lageos 1 and Lageos 2

Since 2017, FSUE VNIIFTRI has been performing LLR data processing. The modern program of UT1 evaluation based on Lunar Laser Ranging measurements were created in the MATLAB environment. Now only ILRS LLR data are processed, but it's ready for processing the Altay LLR station measurements too. Comparison of the results of determination with the concurrent EOP (IERS) C04, the agreement is as good as 60 μ s for the UT1–UTC.

Conclusion

VNIIFTRI has successful experience to measure laser range for EOP 50 years. Carefully calibration of laser station ensures reliable and precise measurements. The achieved results in the field of SLR meet international standards.

Two laser stations of new generation are planned to be established in Irkutsk and Mendeleevo next year. Preliminary tests confirmed declared characteristics in few mm.

References

1. Kaufman M.B., Tsyba E.N. (FSUE «VNIIFTRI») – EOP Evaluation in Main Metrological Center of Russian Time and EOP Service from SLR Data /Metrology of Time and Space. 6th International Symposium (Materials of the Conference) 2012
2. Tsyba E Associate Analysis Center VNIIFTRI (AAC VNIIFTRI)/ 19th International Workshop on Laser Ranging "Celebrating 50 Years of SLR: Looking Back and Planning Forward"/ Annapolis, MD, USA, October 27-31 (Materials of the Conference) 2014